

DESIGN AND FABRICATION OF AQUA SILENCER FOR AUTOMOBILES

ROHIT RAMDAS THAKARE¹ & AJIT JAYVIR KHUSHWAH²

¹BE in Automobile Engineering, PIIT New Panvel, Maharashtra, India

²ME in Mechanical Engineering, YTCEM -Bhivpuri Road Karjat, Maharashtra, India

ABSTRACT

“Aqua Silencer” is an attempt made to deal with the control of overall emissions & undesirable sound at tail pipe of a vehicle, before it is emitted to the atmosphere. It can be fitted along with or instead of catalytic converter at the tail pipe of exhaust system of a vehicle. Sound produced due to operation of an engine can be controlled using water as sound produced under water is less hearable than produced in environment. This mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. Because of this property, water is used in this silencer & hence its name, “Aqua Silencer”. Also there is no effect of it after its installation on fuel efficiency of a vehicle, which may be petrol powered or diesel powered. Exhaust emissions can be controlled using a layer of activated charcoal which is highly porous & possesses few extra valances & has high adsorption properties, so it attracts the hazardous gases towards it & releases much less position to environment. The level of noise & smoke coming out of “Aqua Silencer” is considerably less compared to conventional silencer; also it is cheaper to build & maintain. There is no need of catalytic converter getting fitted with it, give no rise to any complications in assembling it & easy to install.

KEYWORDS: Aqua Silencer, Exhaust Emission, Fuel Efficiency, Activated Charcoal, Environment, Sound Pollution

Received: Nov 13, 2015; **Accepted:** Dec 07, 2015; **Published:** Dec 12, 2015; **Paper Id.:** IJMPERDDEC201511

INTRODUCTION

Internal combustion engines are playing a vital role in road, sea & air transport services for transportation of passengers as well as goods, agriculture, mining & many other industries. Considering the overall available fuel resources in the world & the present technological development, fuel i.e. may be petrol or diesel is evidently indispensable. In general, the consumption of fuel is an index for finding out the economic strength of any country. In spite, we cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. Air pollution can be defined as an addition to atmosphere of any material, which will have harmful effects on the life on the planet. It is also an important issue considering public point of view as an every individual person breaths approximately 22,000 times per day, inhaling about 15 to 22 kg of air every day. Polluted air causes physical ill effects to human beings & environment on earth & causes serious of degradation of health & living standards.

The main contribution to this continuously increasing air pollution is the vehicle exhaust, releasing hazardous gases like Carbon Monoxide (CO), Unburnt Hydrocarbons (UBHC), Oxides of Nitrogen (NOx) & Lead (Pb), etc. Vehicle exhaust is not the only source of air pollution, other sources like electric power generation stations, industrial processing, domestic & industrial fuel consumption, refuse burning etc. also contributes heavily to degradation of our environment.

It is especially so, in most of the countries around the globe, a constant research is going on to reduce

toxic contents from the vehicle exhaust as I.C. engines are finding ever increasing useful application in almost all the fields & their demand is also getting increased day by day.

In order to avoid this ever increasing degradation of environment, serious attempts should be made as large mass of burnt gases getting mixed with the atmospheric air erodes purity of environment & degrades health of human beings & other lives who are inhaling it for breathing & other purposes. Currently, overall exhaust emissions, crankcase blowby & evaporative losses are the main constituents contributing towards exhaust emissions in case of automobiles & the conventional control methods used to reduce these emissions are catalytic converter for getting control over carbon monoxide (CO), unburnt hydrocarbons (UBHC) & oxides of nitrogen (NOx), muffler for controlling undesirable noise at tail pipe of vehicle exhaust system & exhaust gas recirculation (EGR) for controlling crankcase blow by. Evaporative losses of fuel from the fuel tank can be easily avoided by keeping your vehicle parked under shade, instead of parking it under direct sunlight.

“Aqua Silencer” is an attempt made in this direction, which is mainly dealing with the control of overall emissions & undesirable at tail pipe of a vehicle, before it is emitted to the atmosphere. It can be fitted along with or instead of catalytic converter at the tail pipe of exhaust system of a vehicle. Sound produced due to operation of an engine can be controlled using water as sound produced under water is less hearable than produced in environment. This is mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. Because of this property, water is used in this silencer & hence its name, “Aqua Silencer”. Also there is no effect of it after its installation on fuel efficiency of a vehicle, which may be petrol powered or diesel powered.

Exhaust emissions can be controlled using a layer of activated charcoal which is highly porous & possesses few extra valances & has high adsorption properties, so it attracts the hazardous gases towards it & releases much less pollution to environment.

The level of noise & smoke coming out of “Aqua Silencer” is considerably less compared to conventional silencer; also it is cheaper to build & maintain. There is no need of catalytic converter getting fitted with it, give no rise to any complications in assembling it & easy to install.

Objectives

- To reduce harmful gases from vehicle exhaust system such as carbon monoxide (CO), unburnt hydrocarbons (UBHC), oxides of nitrogen (NOx) & lead (Pb) getting mixed with environment.
- To reduce overall temperature of exhaust gases coming out of vehicle exhaust system & thereby reducing the emission of green house gases adding to the global warming.
- To reduce undesirable noise at tail pipe of exhaust system of a vehicle & help to reduce level of noise pollution.
- To select easily available material for outer shell as a resource, so that it can be easily fabricated at a minimum possible cost.
- To design such a model that can be an alternative for conventional catalytic converter, at minimum possible cost.
- To fabricate a designated model in such a way that activated charcoal & water used are easily replaceable & also water from shell won't get mixed with exhaust manifold.

- To generate a compact model as compared to conventional catalytic converter & muffler assembly, so that it can also be easily fitted on a vehicle instead of catalytic converter.

Proposed System

Proposed system is designated to use an adsorption method for reducing overall emission at exhaust tail pipe of an engine, along with which water is used to minimize or reduce the undesirable noise & reducing overall temperature of exhaust gases, which can add to greenhouse gases. The outer shell will be made up of grade-13 galvanized steel sheet which will be approximately 3mm in thickness. Perforated tubing will be placed inside the shell. This system will use activated charcoal, a specially treated charcoal; which will act as an adsorbent to adsorb harmful gases from vehicle exhaust. Regular water will also be used to reduce undesirable noise at tail pipe of an engine & will also help to reduce overall temperature of exhaust gases, which may add to greenhouse gases. Also, this system will make a use of perforated tubing on whose periphery various diameter holes will be drilled so that high mass bubbles will be converted into low mass bubbles & will help to avoid splashing of water outside a tank. This perforated tubing will be further connected to swing check type non-return valve via a specially fabricated flange, using which the perforated tubing can be easily inserted inside the shell & also if there is a need to change the activated charcoal placed inside the wire mesh on perforated tubing, it can be easily replaced by removing the tubing via flange. On the exhaust end of perforated tubing inside the shell, a round shaped support will be provided in which perforated tubing inserted from other end will. Also, the bun plugs along with 2" extension pipes will be provided on upper part & lower part of periphery of an outer shell, which will serve as an outlet for adding fresh water & removing carbon precipitate mixed water. After the flange, there will be a reducer coupling on both the sides, between which a swing check type non-return valve will be placed. On the outer side of reducer coupling, hose pipe reducer will be fitted on which hose pipe can be easily fitted. Also, this unit will be connected to vehicle exhaust system's tail pipe using a hose pipe of 1.5" diameter & jolly clips will be fitted on both its side so that there will not be any leakage or external pressure acting inside it. This proposed system can be easily connected or attached at exhaust tail pipe of any vehicle as it can be used as a prototype & also, it can be easily fitted on any industrial applications. Basically an aqua silencer consists of a perforated tube which is installed at the end of the exhaust pipe. The perforated tube may have holes of different diameters. The very purpose of providing different diameter hole is to break up gas mass to form smaller gas bubbles in the perforated tube of different diameter. Generally 4 sets of holes are drilled on the perforated tube & its other end is closed by a plug which fits inside support provided. Around the circumference of the perforated tube a layer of activated charcoal is provided & further a metallic mesh covers it. The whole unit is then placed in a water container i.e. a fabricated shell. A small opening is provided at the top of the container to remove the exhaust gases & a drain plug is provided at the bottom of the container for periodically cleaning of the container. Also a filler plug is mounted at the top of the container. At the inlet of the exhaust pipe a non-return valve is provided which prevents the back flow of gases and water as well.

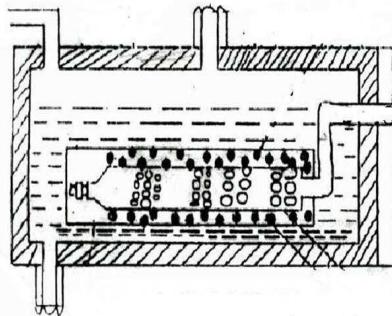


Figure 1: Basic Construction of Proposed System

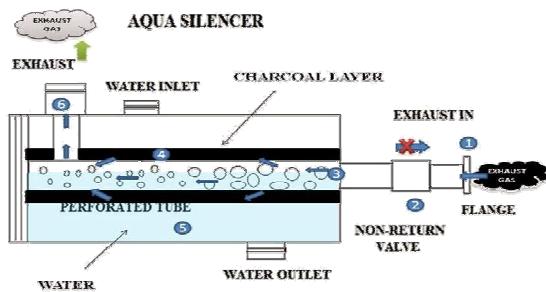


Figure 2: Working Principle of Aqua Silencer

Working Principle

As the exhaust gases enter into the aqua silencer, the perforated tube converts high mass bubbles into low mass bubbles. After that, they pass through a charcoal layer which again purifies the gases. It is highly porous and possesses extra free valences, so it has high absorption capacity. After passing over the charcoal layer, some of the gases may get dissolved into the water, and finally, these exhaust gases escape through the opening into the atmosphere. Hence, the aqua silencer reduces noise and pollution. Activated carbon is more widely used for the removal of taste and odorous from the public water supplies, as it is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption. The water is a good absorbing medium. In this experimental model, the gases are made to be dissolved in water. When these gases dissolve in water, they form acids, carbonates, bicarbonates, etc.

Effect of Dissolved Gases on Water

The water is a good absorbing medium. In the aqua silencer, the gases are made to be dissolved in water. When these gases dissolve in water, they form acids, carbonates, bicarbonates, etc.

I: Effect of Dissolved SOx: When SOx is mixed in water, it forms SO₂, SO₃, and H₂SO₄, i.e. sulfuric acid, which forms hydrogen sulfide, causing a foul rotten egg smell, acidification, and corrosion of metals.

II: Effect of Dissolved CO₂: The dissolved carbon dioxide forms bicarbonate at lower pH and carbonates at higher pH. This level is 40-400 mg/liter. This forms scale in pipes and boilers. Carbon dioxide mixes with water to form carbonic acid. It is corrosive to metals and leads to polluting greenhouse gases.

III: Effect of Dissolved NOx: The nitrogen in water undergoes oxidation to form ammonia, nitrate, nitrite, and nitric acid. This synthesis of protein and amino acids is affected by nitrogen. Nitrate usually occurs in trace quantities in surface water. A limit of 10 mg per liter of nitrate is acceptable in drinking water.



Figure 3: Fabricated Assembly- Aqua Silencer

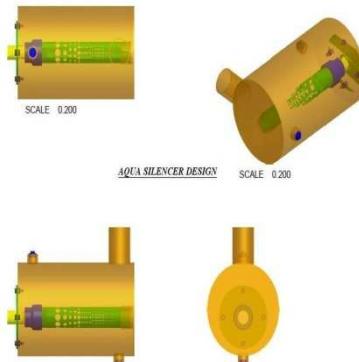


Figure 4: Pro-E Model of Aqua Silencer (Internal Structure)

Experimental Analysis

For experimental analysis we took a trial test where we fixed the model of Aqua Silencer", which we have fabricated to the exhaust tail pipe of a vehicle using a hose pipe on which a jolly clip is fitted so that there will be minimum possible leakage of exhaust gases from vehicle exhaust & pollution analysis tests were conducted on petrol as well as diesel engine.

As per our aim of project discussed, there are basically 3 objectives of "Aqua Silencer", which are as follows:

- Reduce pollution level by reducing NO_x, CO & UBHC contents.
- Reduce undesirable noise level at tail pipe.
- Reduce overall temperature of exhaust gases.

For these above objectives following tests were carried out, that are listed below

- PUC Test on Multi Gas Analyzer (NETEL NPM-MGA-1) on Petrol Engine of 2001 Maruti Suzuki WagonR (5-Speed MPFI BS-II).
- PUC Test on Smoke Meter(Netel NPM-SM-111B) on Diesel Engine of 2012 Maruti Suzuki Ertiga (5-Speed DI BS-III).
- Decibel Meter for Sound Level Measurement.

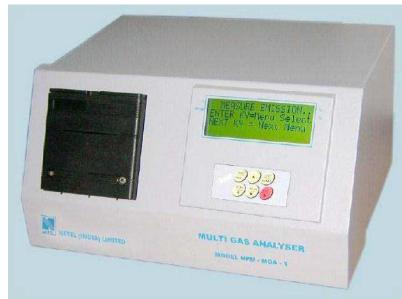


Figure 5: Netel Multi Gas Analyzer NPM-MGA-1



Figure 6: PUC Certificate- Petrol Engine

Table 1: Result Comparison: Petrol Vehicle

Parameters Considered	Before Implementation of Aqua Silencer	After Implementation of Aqua Silencer
Carbon Monoxide (CO)	0.039%	0.017%
Hydrocarbons (HC)	91 ppm	59 ppm
Oxides of Nitrogen (NO _x)	100 ppm	2 ppm



Figure 7: Netel Smoke Meter NPM-SM-111B



Figure 8: PUC Certificate- Diesel Engine

Table 2: Result Comparison: Diesel Vehicle

Parameters Considered	Before Implementation of Aqua Silencer	After Implementation of Aqua Silencer
Smoke Density In	09	07
Hartridge Smoke		
Units		

RESULT DISCUSSIONS

We obtained the final results of pollution analysis tests before & after installation of „Aqua Silencer“ on vehicles equipped with petrol & diesel engines. Then, we have also compared these results with each other; so that we can find the total efficiency as well as effectiveness of the system of „Aqua Silencer“ which we have designed & fabricated. We, then also compared these after results with Bharat Stage Emission Norms in order to find that in what category of emission norms the vehicle that is installed with a system of „Aqua Silencer“ fits in

Table 3: BS-III Emission Norms- Petrol Vehicles

Emission Standards for Gasoline Vehicles (GVW ≤ 3,500 kg), g/km

Year	Reference	CO	HC	HC+NO _x	NO _x
1991	-	14.3-27.1	2.0-2.9	-	
1996	-	8.68-12.4	-	3.00-4.36	
1998*	-	4.34-6.20	-	1.50-2.18	
2000	Euro 1	2.72-6.90	-	0.97-1.70	
2005†	Euro 2	2.2-5.0	-	0.5-0.7	
2010†	Euro 3	2.3	0.20	-	0.15
		4.17	0.25	-	0.18
		5.22	0.29	-	0.21
2010‡	Euro 4	1.0	0.1	-	0.08
		1.81	0.13	-	0.10
		2.27	0.16	-	0.11

Table 4: BS-IV Emission Norms- Diesel Vehicles

Emission Standards for Light-Duty Diesel Vehicles, g/km

Year	Reference	CO	HC	HC+NO _x	NO _x	PM
1992	-	17.3-32.6	2.7-3.7	-	-	-
1996	-	5.0-9.0	-	2.0-4.0	-	-
2000	Euro 1	2.72-6.90	-	0.97-1.70	0.14-0.25	-
2005†	Euro 2	1.0-1.5	-	0.7-1.2	0.08-0.17	-
2010†	Euro 3	0.64	-	0.56	0.50	0.05
		0.80	-	0.72	0.65	0.07
		0.95	-	0.86	0.78	0.10
2010‡	Euro 4	0.50	-	0.30	0.25	0.025
		0.63	-	0.39	0.33	0.04
		0.74	-	0.46	0.39	0.06

CONCLUSIONS

“Aqua Silencer” can be said to be an advanced system which can be used along with or instead of a catalytic converter, using which exhaust emissions at tail pipe of an exhaust system can be easily lowered than specified levels, along with reducing undesirable noise at tail pipe. Also, the use of water decreases overall temperature of exhaust gases coming out via tail pipe, which may add to greenhouse gases. Overall emissions at tail pipe which contains harmful constituents like lead (Pb), carbon monoxide (CO), oxides of nitrogen (NOx) & unburnt hydrocarbons (UBHC) can be lowered than existing levels using adsorption method, which uses activated charcoal to adsorb these harmful constituents. Water is mainly used to suppress or reduce the level of undesirable noise at exhaust tail pipe & it also acts to help in bringing down overall temperature of exhaust gases. By using the perforated tubing, there will not be any excessive back pressure formation as high mass bubbles get converted into low mass bubbles. Also, fuel consumption remains same after implementation of this system. Contamination of water is also found to be negligible after implementation of this system. It is also cheap to build & maintain, compared to conventional silencer system.

This system can be used on petrol as well as diesel engines, & also in the industries which makes the use of fossil fuels for power generation system i.e. it can be applied on both, mobile & stationary applications

Future Scope

There are still many things & changes to be implemented in this system which we have designed, so that this system can work more effectively & efficiently. In the future, we can implement/ provide the following systems/ changes in “Aqua Silencer” for its efficient working:

- Reducing the overall weight of a system, by making it handy to carry anywhere whenever required.
- Instead of regular tap water, distilled water or coolant can be used.
- Water level indicator can be provided to have an indication of water level inside the shell.
- Providing automatic & continuous water circulation using sprinklers or spray jets.
- Using double pass vertical perforated tubing instead of single pass horizontal perforated tubing.
- Using baffles at exhaust inlet, instead of non-return valve.

REFERENCES

1. *Internal Combustion Engines- M.L. Mathur & R.P. Sharma*
2. *Automotive Mechanics- W.H. Crouse & D.L. Anglin*
3. *Automobile Engineering- R.B. Gupta*
4. *Environmental Pollution Analysis- R.S. Khopkar*
5. *Maruti Suzuki WagonR (5-Speed) MPFI*
6. *Maruti Suzuki Ertiga (5-Speed)*
7. *Netel Exhaust Gas Analyzer- NPM-MGA-1*
8. *Netel Smoke Meter- NPM-SM-111B*

9. Autocar India Professional
10. Overdrive Professional
11. SAE Monthly Magazine
12. www.suneetachemicals.com/activecarbon
13. www.suneetachemicals.com/activecarbon_gl70.html
14. www.docs.google.com/patents/us3795730
15. www.docs.google.com/patents/us4926590
16. www.docs.google.com/patents/us4624937
17. www.patentonline.com/activecarbonexhaust.html
18. www.uspatents.org/nox_scrapper.aspx
19. www.uspatents.org/petrol_exhaust_treatment.aspx
20. www.uspatents.org/diesel_exhaust_treatment.aspx
21. www.ipiindia.nic.in/diesel_exhaust_scrapper.html
22. www.wikipedia.com/wiki/activated_carbon
23. www.wikipedia.com/wiki/vehicle_exhaust
24. www.wikipedia.com/wiki/exhaust_gas_recirculation
25. www.wikipedia.com/wiki/bharat_stage_norms
26. www.wikipedia.com/wiki/euro_emission_norms
27. www.wikipedia.com/wiki/hydrocarbon_emission
28. www.mahatranscom.in/pollution_control
29. www.mahatranscom.in/pollution_level/metro
30. www.cpcbindia.nic.in/emission_norms.html
31. www.cpcbindia.nic.in/emission_level_petrolengine
32. www.cpcbindia.nic.in/emission_level_dieselengine

